INTER-AGENT INTERACTION IN MEDICAL INFORMATION SYSTEM: CASE HOMECARE

[1]KARIM ZAROUR, [2]NACEREDDINE ZAROUR, [3]SOUHEILA KHALFI

[1,2,3]LIRE laboratory, Department of Computer Science, University Mentouri of Constantine,

BP 325, Route Ain El Bey 25017 Constantine, Algeria

E-mail: karim.zarour@umc.edu.dz, nasro-zarour@umc.edu.dz, khalfi.souheila@yahoo.fr

ABSTRACT

Medical information systems evolve constantly. Homecare is a part of these systems. Nowadays, the organization of homecare arouses an increasing interest. By organization, we mean particularly the choice of partners, distribution problems, tasks coordination, and the resolution of all participants' resources-conflicts that implies a reliable communication. The quality of the homecare relies on competences, qualifications, and the organization of the participating partners. So, it is necessary to assure a permanent interaction. It is evident that the agent paradigm is the most suitable one for modeling the homecare organization since it is capable of taking into account all its properties (heterogeneity, distribution, decision making, etc.). In this paper we would like to present interactions in an agent-based architecture for a cooperative information system that supports the homecare and contains all the necessary constituents for its functioning.

Keywords: *Homecare, Interaction, Cooperative information system, Multi-agent system, Ontology.*

1. INTRODUCTION

Current information systems do not operate any more only in their own localization, but they participate in virtual environments to form Cooperative Information Systems (CISs) [1] which represent at the moment a considerable stake. In our working context, the homecare is a temporary virtual organization, constituted of a set of cooperating partners belonging to diverse institutions supported by autonomous and heterogeneous information systems. Performances and the efficiency of a homecare organization result from the implemented cooperation, decisions taken, capacities, competences and resources offered by the various participant partners. Furthermore, the homecare takes place in a particularly mobile and dynamic environment. It evolves constantly during its existence [2]. The real issue in a homecare system is that of its organization rather than the lack of means it posses.

Our purpose is to develop a CIS adapted to the concrete needs of the homecare and to interoperate the participating systems with respect to their autonomy, i.e. an architecture which allows the sharing, the fast and supple exchange of information, and opens new perspectives of flexibility and adaptability to applications which are dedicated to the homecare. In this perspective, the multi-agent paradigm [1][3] proposes interesting concepts for the CIS development, such as the control autonomy, the decentralization, and the communication.

The interaction is the base of problems' cooperative resolution since the homecare partners must communicate between them, as well as with services of the platform supporting the homecare organization or with the environment. In our work context, we want to say by the interaction, the communication, the collaboration and the negotiation. Several mechanisms of communication are possible, exchange and sending of messages, methods invocation, or the use of a blackboard. In consequent, standardized inter-agents communication languages must be supplied.

Some approaches were proposed in the homecare domain [2][4][5][6]. However, these works generally consider the homecare as a simple service which is used to support a given property like medical surveillance, coordination, or mobile technology. Furthermore, these systems are dedicated to particular homecare scenarios.

Therefore, we notice the lack of a generic system of homecare which leads to interaction problems like communications that must be user-centred, interoperability, and reusability.

The objective of this work is to show how an agent-based architecture, named ABAH1, for a CIS supporting the homecare, permits flexible interactions to increase cooperation among distributed homecare partners.

The rest of paper is organized as follows. In section 2, we present the suggested architecture and describe its components. Section 3 shows how interactions between homecare partners are made in ABAH system and the different phases for the constitution of a homecare organization. Section 4 gives some advantages of using the mobile communication tools. A prototype implementation of ABAH and experimental results are presented in section 5. In section 6 are presented some related work were we review some existing approaches followed by a discussion in section 7. Section 8 summarizes the contributions of this paper and points at directions for future work.

2. AN AGENT-BASED ARCHITECTURE FOR THE HOMECARE

The homecare implies an asynchronous cooperation between partners belonging to distributed and autonomous Information Systems (IS) (necessarily, they were not designed to work together). The homecare is situated in a complex, mobile, evolutionary environment and emerging a distributed knowledge. According to the theory of agent paradigm, it is evident that this last one is the most suited to take into account these characteristics. Thus, this work purpose is to build an agent-based architecture, which supports the flexibility and sociability in the homecare. Agents are capable of interacting between them to interpret and accomplish their tasks; particular in the situation where agents have not all the same local purposes (e.g. the psychologist agent is interested only in the patient agent psychological state, the nurse agent for the nursing, etc.). In fact, agents form a cooperative and intelligent multi-field system. Also, the communication mechanisms recommended by the agent approach supply elegant and satisfactory solutions.

The proposed architecture, named ABAH, modeling the CIS that supports a homecare organization is agent-based (see figure 1), in which each partner is represented by an agent. This architecture facilitates the interoperability, the accessibility to information, and it supplies to homecare partners the same functionalities as if they belong all to a single structure (the same place) [7]. The interoperability appears with our organization, as another element indispensable to its success, rather a necessity and consequently heterogeneity mastery [8]. For that, it is advisable to adopt norms and common standards to the system arrangement. These standards allow to assure partners agents to exchange, or to transmit information and transparent totally knowledge, to allow a better functioning of homecare organization. Indeed, it is a question of resolving the syntactical and semantic conflicts of the shared information to cooperate in term of communication.

Our agent-based architecture is independent from any application in the field of patient's homecare (chronic diseases, old persons, etc.). In summary, we want that our system quickly adapts itself to changes of its environment and in order to retain the agents' autonomy.

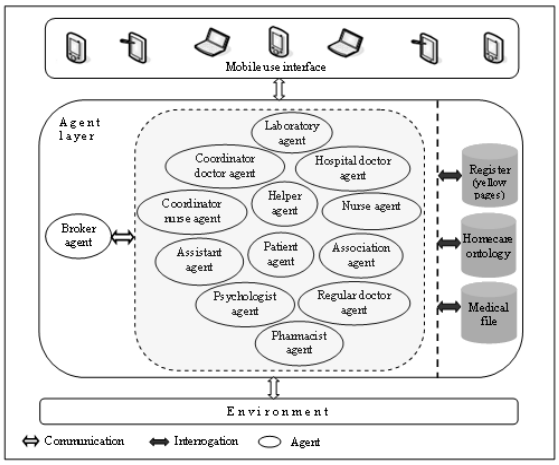

Figure 1. ABAH: agent-based architecture of the CIS supporting the homecare

2.1 Description of ABAH components

The architecture ABAH (figure 1) is composed of a set of partners agents. It forms a real autonomous, cooperative and multidisciplinary team, represented as a society of cooperative agents to satisfy a common purpose which is the care of the patient at home. We have classified these agents into three groups: medical agents, paramedic agents, and helper agents.

The medical agents: They are linked between them by an inter-professional collaboration. We find the coordinator doctor agent takes care of tasks

[1] Agent-Based Architecture for Homecare

decomposition and follows the run progress of various sub-tasks of all agents. Consequently, it transmits information systematically to the broker for partners' selection and the contract negotiation.

The regular doctor agent has direct contacts with the patient agent . It is its privileged interlocutor.

The hospital doctor agent has fewer contacts among the medical agents with the patient agent. It plays the expert role during a hospitalization or a re-hospitalization in collaboration with the coordinator agent doctor and the regular doctor agent.

*The pharmacist agent v*erifies prescriptions and delivers medicines prescribe by the doctor agents.

The laboratory agent puts back the necessary information of analyses results prescribed by a medical agent.

The paramedic agents: In this particular case, *the nurse agent* and *the assistant agent*, that assure monitoring and continuous care in permanent coordination with the coordinator nurse agent, the set collaborates with the medical agents and the helper agents.

The helper agents: They collaborate in homecare, they represent a moral and physical support due to their advices and orientations, to reduce every appeared imbalance. They allow a concordance between the processing and the social life, and to assure the coordination with the medical social services. We find *the helper agent*, *the association agent* and *the psychologist agent.*

All these described agents intervene at a certain moment to accomplish specific tasks which correspond to their competence (know) and their capacities during homecare process (know how). ABAH contains other components as:

A *broker* agent for the search and the intelligent, dynamic and optimal selection of partners, it facilitates the mechanism of negotiation.

A *database,* it is a question of medical file which represents a homogeneous structure for all partners.

A *homecare ontology* which consists to exchange and share knowledge without ambiguities, it is vital for an organization.

A *register* (yellow pages) contains agent's profile and coordinates for a partial selection of partners.

A *mobile use interface* for the communication and the collaboration of all partners agents so that they cooperate, by taking into account their mobility.

ABAH is completely distributed in the sense where every agent can communicate with another one of the organization without going through by an intermediary (a total distribution of the knowledge, the competence and tasks on partners agents).

2.2 Type of the adopted agents

In the proposed architecture, we used two types of agents, the partner agent and the broker agent. The considered agents are cognitive. They are capable of foreseeing and anticipating actions. Their key characteristics include the autonomy and also flexibility (sociability and pro-activity). Furthermore, seen that information are of dynamic nature, their growth is important, and they can carry certain expertise (transfer knowledge) which influence directly on the decision-making (semantic view point of data). Indeed, the adopted agents allow:

- supply of coherent and dynamic data without any ambiguity,
- addition and access to information,
- traceability, broadcasting and information propagation,
- activities history conservation.

Therefore, each type of agent aims at manipulating the transfer and data acquisition with an important reliability and efficiency. This leads towards update constantly pertinent information, consequently the adopted agents must be also informative.

3. THE INTERACTION IN ABAH

The communication is considered in all steps of ABAH life cycle. Agents communicate in the aim to coordinate their tasks during the homecare process. The forming and the constitution of the homecare go through three principal phases, a best offers selection of the potential contracting parties, then the contract negotiation and finally the care itself.

The cooperation is the organization permanent preoccupation, it is an asynchronous interaction since those partners meet rarely and belong to different structures. They succeed one another for

the care continuance. So, all roles of partners are based on their interactions. Agents cooperate, exchange information according to their roles, tasks and conventions which they are attached. When an agent becomes an organization member of the homecare, it puts update its knowledge base and its plans library, plans its tasks, determines then fixes its local purposes. Therefore, it has to coordinate its tasks to better cooperate by assuring the care continuance, and improve the quality of service.

The homecare is a temporary organization formed from partnerships contracts which can dissolve when their common interest is achieved. So, the homecare organization ends and dissolves when the homecare is totally accomplished, a decision to stop is taken by the medical agents (consensus), or the death of the patient agent. We show in the next subsections, how through the three phases partners participate fully via interactions in building the homecare organization.

3.1 The selection phase

For a good progress of the selection phase we opted for the Contract-Net protocol[9] used in auctions and solution of the distributed problems. In our context, we adapted this protocol for the choice and the preliminary selection of partners candidates to consider in the contract negotiation. The coordinator doctor agent sends a message to the broker agent by determining the profile wanted for a corresponding task. The last one stores the relevant information in its knowledge base to carry out its search. As a consequence, the advantage of the use of such a broker is to minimize messages exchanges and the execution time of the selection. Therefore, the broker agent:

- announces the task to make to the interesting contracting parties (call for proposal);
- requires answers in determined period (a patient agent which waits);
- receives and estimates the potential contracting parties submissions;
- selects the best potential contracting party.

And, the contracting party:

- receives task offer to make;
- estimates possibly its capacity to answer to this offer;
- interested by offer it becomes a potential contracting party;
- sends a message to broker to confirm whether it agrees to realize the offer corresponding task
- waits its selection confirmation.

Offers are estimated by using a multi-attribute utility function [10]. Each attribute is balanced. The choice of the potential contracting parties depends on the value of the obtained utility described as follows:

Utility Value = $\sum$ (attribute value * weight)

The evaluation is based on attributes values (i.e. the criteria of partners selection) included in the utility function and weights (stored in its knowledge base) which are assigned. For every selection criterion, the broker attributes it a value. Example: experience 5 years, then the broker attributes it the value 5 * 15 %. The result is an evaluation value added to the other values of attribute (selection criteria) to give the utility value for every interested agent. The utility function can be changed by choosing different attributes and\or by changing weights which are assigned to attributes.

The task will be attributed to the contracting party that presents the best offer. The broker bases itself on this order to select another contracting party if the current member refuses to commit itself or the response time is exceeded. The interest to classify offers is to avoid the broker to begin again a new process of selection when a contracting party refuses to commit itself for a given reason. The process stops when there is no more offer on behalf of the broker and when all tasks are attributed. The figure 2 shows clearly this phase:

- First of all, agents interested by homecare, join the register (yellow pages), this last one records agents descriptions as well as services which they offer. Then, any agent interested in particular services, demands to register to discover services offered by the other agents, i.e. the adequate profile for which an agent looks. In ABAH, the coordinator agent sends a list of partners agents profile to the broker agent which can participate in the patient agent care. So, the system allows every agent wishing to participate in homecare, to join the yellow pages by defining its profile and its services. During the life cycle of broker agent, it acquires a certain experience allowing it to progress, to improve and finally to master its search.

- After that agents are register in the yellow pages, and that now any information and service interested by other agents, the broker agent in the occurrence, are accessible through the register. In particular, the broker agent is interested to determine a well profile (example: psychologist agent specialized in the homecare field, experimented, etc.) to avoid losing of selection time and possibly, a precious time of negotiation. Generally the selection phase and the negotiation phase end to a numerous and complex information exchange (according to agents' number to communicate).

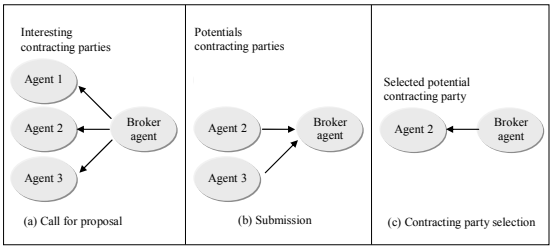

Figure 2. The process of the selection phase of a potential partner agent

3.2 The negotiation phase of contract and commitment

The role of contract negotiation is to determine, in a formal way, the agreements of the commitment. The coordinator doctor agent determines tasks which every agent has to carry out during its partnership, by clarifying the responsibility, the purpose, and the mission of each one (type of task, lasted, contact, etc.) within the system, and then it informs the broker. The mechanism of contract negotiation which we adopted is based on exchanges of propositions and counterproposals. This negotiation is based on a compromise, therefore, there are exchanges of messages and information (suggest, accept the proposition, reject the proposition and against propose, etc.) between the agent broker and the potential contracting parties until the finding of a total assent. The end of this negotiation is the establishment of a contract. Therefore, the potential contracting parties become official partners. The result of the negotiation is sent to the coordinator doctor agent. If for any reason, the contracting party refuses to commit itself during the process of negotiation then, it informs the broker. Otherwise, this last one will know when the contracting party will exceed the maximum reply time. In that case, the bargaining between these two agents stops and the broker is not going to undertake in another process of selection to find an agent that will replace the one which refused to commit itself. Rather, the broker just consults the classification of the contracting parties of the selection phase and will choose the following one. The figure 3 shows clearly this phase:

- Further to the selection of the potential agent, the broker agent enters with this last one in a negotiation phase (propose, accept-propose, etc.) to determine formally the contract clauses and becomes so an official partner agent. The coordinator doctor agent receives a confirmation message on behalf of the broker agent, confirming the agent partnership.

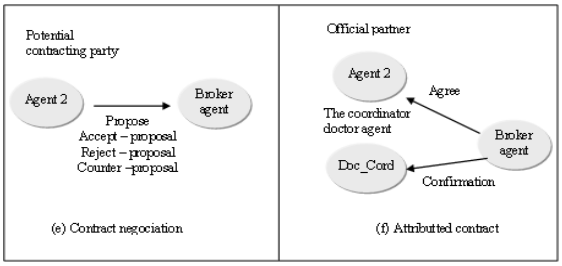

Figure 3. The process of the negotiation phase of contract and commitment

3.3 The patient care phase

Further to the commitment and the elaboration of contracts and agreements, comes effectively the care process. In parallel we find the logistic process (inspired of [2]), i.e. to set up the medical equipment and the material necessary for the care. All partners assure a cooperation of competence around a protocol of care supervised by the coordinator doctor agent. Every agent plans and coordinates its tasks with the other cooperative agents, by establishing the necessary organization of the execution of its actions. For every action, the agent verifies if it belongs it then it carries out the action (check of the role which it plays in the organization), updates its knowledge base and its plans library. Any taken decision, note or action must be remembered in the medical file, so any intervention trace is kept.

The collaboration in the organization requires respect of confidentiality of patient's state. Every agent consults only information which concerns it according to the access rights (example: only the doctor agent can write a prescription and that the

agent patient can have access, the helping agents and the ancillary medical agents can make reports, etc.). Every agent has to be up to date on any new information, and a part of its function is to brought to knowledge any situation and pathological state of the patient agent. The coordinator doctor agent watches that partners agents respect their commitment. Agents are of different fields of activity, and communication is made without ambiguities to exchange information and knowledge. Therefore, an ontology for the homecare is seemed necessary for the cooperation. In the heart of conflicted situations that are very difficult to manage, the agent asks for an inter-professional collaboration to improve the service, and which each in its domain brings its competence. Besides, the care evaluation is permanent, and according to the report of every partner agent, the medical agents negotiate to make decisions by consulting the database (medical file) or by so necessary direct communication.

If an organization member violates the commitment, or it does not answer any more messages during the care process, then the coordinator doctor agent informs the broker to find a substitute. The broker has to re-negotiate again with another agent (the following one in the classification) to replace the one which abandoned.

In ABAH system, for every patient agent admitted after evaluation of its situation, the care process at home starts, i.e. the logistical process and the care process. So, all partners agents participating in the care (medical, ancillary medical and helping agents) constitute an organization including the concerned patient. Therefore, an organization takes care of a single patient at the same moment. Furthermore, partners agents can participate in several organizations. Thus, a partner agent can cooperate in various organizations of homecare, or only in one organization. The figure 4 shows clearly that we can find partners agents in more than one organization. This last one takes care only of a single patient at the same moment.

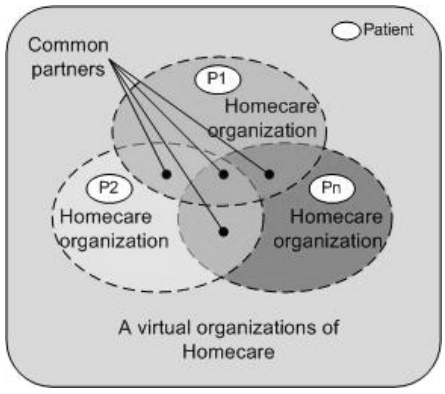

Figure 4. Common partners agents between organizations

3.4 Common communication protocol

The success of ABAH also depends on an effective communication throughout its progress. Really, to analyze data, identify information, maintain knowledge, communicate syntheses, recommendations and decisions-making of agents that are different by their functions and activities, require an unfailing communication mechanism.

The adopted communication mode is messages sending. This mode adapts itself well with the system ABAH. Indeed, the organization's global behavior is totally distributed on the various agents that are implied, contrary to the sharing mode which imposes data centralization. Also, this communication mode can have an impact on tasks coordination in the organization. Hence, the suggested coordination mechanisms are based on exchanges of propositions and counterproposals. The selection criterion of the communication language is based on the one that favors most the interoperability. The success of information diffusion between partners resides certainly in the communication protocols standardization. Moreover, it supports the conversational aspect which is perfectly convenient for our organization. In the occurrence the language ACL FIPA [9] becomes the inescapable standard for the agents interaction (see example in figure 5).

```
(inform
:sender   Nurse agent
:receiver Regular doctor agent
:language XML
:ontology OntoPAD
:content (<report>
              < clinical exam>
                  <weight> 54 </weight>
                  <tension> 14-8 </tension>
                  <fever> 37 </fever>
              </clinical exam>
              <conclusion>
                  <ecg> normal </ecg>
              </conclusion>
          </report>
           )
)
```

Figure 5. An example of a message in ACL FIPA containing a report structured in XML

3.5 Sharing medical file

The sharing of medical information is vital in the medicine concerning at the same time: diagnosis, prognosis, analysis and care continuance. It is a progress factor for a better homecare faster and adapted, and so, systematically transmits information to the other participants. Indeed, the medical file is an essential tool to share information to cooperate. It consists in grouping an important number of information, to be able to store and consult them, even to use them easily in distance. The adoption of the new technologies of information and communication in the modern and contemporary medicine transforms gradually the usual medical file into a digital medical file. To improve information traffic and the ABAH intern functioning, the medical file is primordial. It is based on roles (coordinator of care), data, information and knowledge (see figure 6 inspired of [11]). Whose advantages are:

- Minimize the medical errors
- Accelerate knowledges diffusion
- Help to the decision
- Minimize procedures' variability and to the care access
- Answer to modalities' evolution of pick-up charge

It is brought to evolve and to be more updated frequently, it allows a permanent communication between partners agents in an interprofessional context in order to cooperate, and to inquire mutually their conclusions' result and actions. Every agent partner has to find any indication and any information which are useful for the situation understanding: to keep information traceability, to orchestrate, to organize interventions, to share and to exchange information to assure the coherence interventions, the continuance and the care quality.

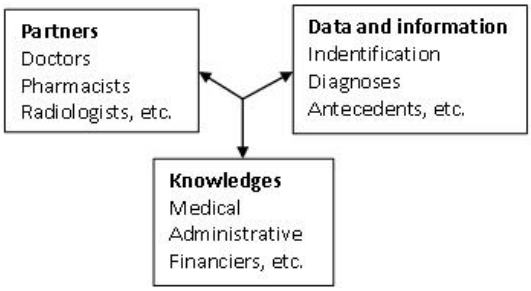

Figure 6. The medical file in ABAH

Our database serves as a medical file (we impose the use of a RDBMS), it guarantees:

- The interoperability between partners agents general view in the sense of coordination to collect, enrich and exchange structured medical data.
- The interoperability between organizations of health reference in the sense of the passage of a patient agent of a care's structure to other.

Furthermore, a virtual collaborative working space reserved for all partners' members of the homecare allows them to work while being geographically taken away and by keeping a permanent assistance around the patient.

3.6 Homecare ontology (OntoPAD)

XML supplies a syntax defined well for the structured documents but no imposes any semantic constraint on the meaning and the sense of these documents. Indeed, it is essential to favor the semantic interoperability for a common and homogeneous understanding of data. The specificity of semantic interoperability defines a common language allowing partners agents to interpret in a homogeneous way the nature and values of data transmitted without ambiguities (a message can be interpreted in several ways) to reason, and to reuse them without error or loss of information.

Our contribution also concerns the representation of these data and knowledge (at the semantic and syntactic level) to allow their sharing, their reusability and especially to reason in order to take the best decision. Indeed, the semantic conflicts result from different interpretations of

information shared between various partners agents of homecare.

These last years, ontology became a subject of appreciated search in different communities, for a better exploitation of information and the semantic sharing between the medical information systems [12] which became a challenge. It is a separate domain of the search in knowledge engineering and their reusability. Ontologies are very promising and participate to surmount the semantic interoperability problem indispensable to communication and exchange data particularly in medicine.

We intend at present to use a simple ontology with concepts simplified to enrich our work, putting in evidence structures of common information. This turns out indispensable to assure common semantics between partners agents of homecare, i.e. the formal information (the figure 7 shows an example of logical axioms to use in ontology).

(…….)

//--- The following axioms allow to define the domain, the co-domain and the relations characteristics. ----//

∃HasForDocument.T⊆Patient

T⊆∀HasForDocument.Document

HasForDocument≡isDocumentOf-

T⊆≤1isDocumentOf

∃contain.T⊆PrescriptionMedicinal

T⊆∀contient.ElementPrescription

contain≡Part-

T⊆≤1Part

(……..)

//--- The following axioms allow to define the domain and the co-domain of an attribute example which is name. The same is realized on all the attributes of every concept. ---//

∃name.T⊆Person

T⊆∀name.string

∃ age.T⊆Person

T⊆∀age.int

(…….)

Figure 7. Partial view on axioms of roles

So, an ontology is vital for the homecare (i.e. badly interpreted information can put in danger the life of the patient). Actually, we opted for OWL ontology [13] possessing the following advantages:

- capacity to be distributed through large systems,
- scalability for the needs of Web,
- compatible with the Web standards,
- open and extendable.

The ontology is baptized OntoPAD (homecare ontology, in french: Ontologie pour la Prise en charge des Patients A Domicile). We give in the figure 8 a preview of the ontology OntoPAD published under Protégé [14].

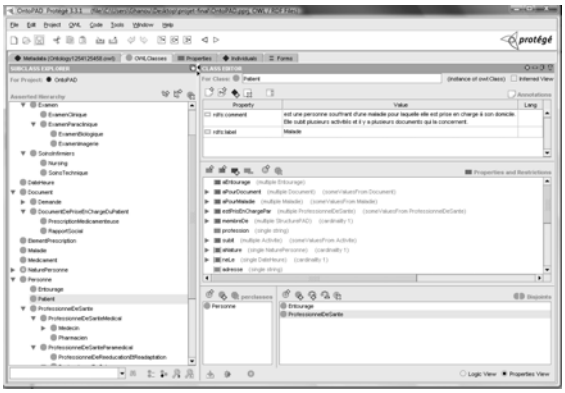

Figure 8. OntoPAD published under the PROTEGE tool

According to the literature which we consulted, architectures were proposed for the homecare we noticed the lack of ontology in their works [15][16], while others foresee them, but which was not developed [6][5]. Thenceforward, domain ontology allows all homecare intervenient (health professionals, patients and families) to share a common understandable vocabulary devoid of any ambiguity and supplies them then the same vision of the domain. The process which we followed for the ontology construction consists of five phases: needs specification (it is a question of establishing an informal document see figure 9), conceptualization, formalization, operationalization and evaluation. Indeed, these various phases are inspired from certain studied methodologies [17][18]. These last ones are those who allow the ontology construction from zero. Besides, we held account of advices and principles of ontological engineering widely accepted and estimated by domain's experts.

knowledge Domain
Homecare Domain .
Objective
Allow the various actors of the homecare to have a common abstract vocabulary which allows them to share in a collaborative way the medical knowledge and to communicate easily.
Users
Patients, Professionals of medical health, Professionals of paramedical health medical, etc.
Sources of information
Technical documents in touch with the homecare domain and the Medical encyclopedia.
Scope of the ontology
Patient, Health Professional, Physician, Medicament, name, Physical Exam, Homecare structures, Document, etc.

Figure 9. Specifications document of OntoPAD needs

4. MOBILE COMMUNICATION TOOLS

The means of the communication and the diffusion allow rendering any useful information directly accessible at the opportune moment by different actors involved in the organization, i.e. the capacity to interoperate simultaneously with the other heterogeneous systems.

Partners agents of the homecare are different in terms of forming, competence or task to be carried out. This variability is translated by a perception mechanism of knowledge and various access modes to information. Then, it is necessary to take into account this variety, for offer to partners the adapted and efficient interaction modes, a better diffusion, and a data acquisition to interoperate. Mobile tools such as PDAs and the mobile phones, which take advantage of the WAP technology to access Web, constitute a real condition for the homecare success. Their uses on behalf of all the participating agents appear the power to share information, knowledge and taken decisions by cooperating (figure 10). As a consequence, it is a question of guaranteeing the quality of service (QoS).

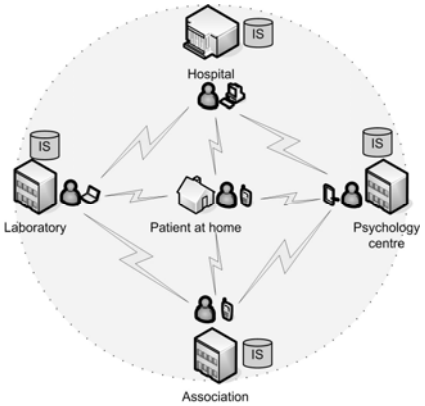

Figure 10. The homecare network

5. IMPLEMENTATION

In order to show how ABAH can be used and the feasibility of using it, we give a prototype implementation. Then, we show how it has been validated by simulation.

5.1 A prototype implementation

We implemented a prototype using standards. We used XML technology to represent the information exchanged between agents via the standard communication language ACL-FIPA. For the development we opted for Java. This language is chosen for its portability and its considerable contribution in the application development. JADE [4][19] is a platform chosen as the deployment of our system. It is a platform which takes into account the FIPA specifications for the multi-agent systems interoperability. Figure 11 presents the implementation of ABAH as a virtual system of patient care at home by using JADE, where every agent of the organization is launched in a separate host and in a different container.

Our implementation is based on the communication during the homecare process, i.e. the search phase for partners, the phase of the organization establishment of homecare, and during the care phase.

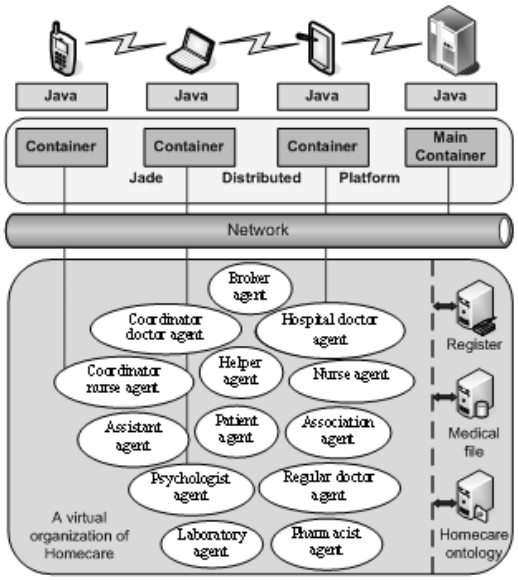

Figure 11. Implementation of ABAH using Jade

5.2 Experimental results

To see the quality and the performance of our system in the aim to evaluate and validate it, we

take the planning example. So, we are going to compare ABAH with a similar work [4] which proposes a support system for home care service based on multiagent system. The simulation is made using the Jade platform for the two compared systems. The fiure.12 shows that the planning is totally centralized, because every message of the proposed system [4] passes by the Scheduler. Contrary, the figure 13 shows that the message exchange during tasks planning in the ABAH system is completely distributed (e.g. tasks planning between the nurse agent and the psychologist agent). Furthermore, no centralized or intermediate agent whose set or a part of messages passes by it (e.g. the coordinator doctor agent). One may notice that the planning activity in the system proposed in [4] (figure 12) required more messages than ABAH system (figure 13) and consequently more time.

To understand better the functioning of tasks planning in the ABAH system, we consider the following example (figure 13): during the care of an old person at home, we suppose that the nurse agent (A) wants to carry out tasks A1 (measure the tension) and A2 (verify the glycaemia). The psychologist agent (B) wants to carry out the task B1 (therapy session). Each has to intervene nearby of the patient agent to carry out its task. Then, to avoid any activity conflict and resources use, both agents coordinate by distributed planning their plans.

- Every agent decomposes its tasks, generates and initializes its local plans. Initially, every agent has only a resolution sight of local problems of its own activities. Tasks of every agent have a duration and a deadline.
- Every agent constructs its local plan based on its local sight.
- Exchange of plan and information between the agent A and the agent B. Therefore, if activity conflicts occur, both agents coordinate, they exchange and compare their structure of tasks to find a solution. In our example, we suppose that both agents found a classification which is the execution of the task A2 before the task B1.
- A is going to carry out the task A2 before the task A1 by sending a commitment to B. Then B reorganizes its plan and executes its task. It is going to wait for the execution of the task A2, then carry out the task B1. Thus, it re-plans its plan to benefit advantages of this execution.

This example shows a basic coordination in the GPGP [20] technique. Every agent elaborates its own plan locally and coordinates it in a distributed way. It reacts to the not foreseen situations by modifying its plans, i.e. an alternation between planning phase and execution phase. The time is a part of purposes of agents and the negotiation for conflicts resolution.

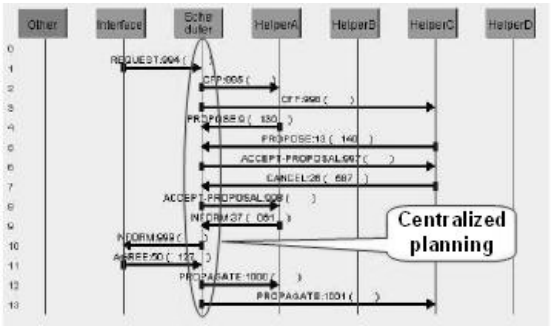

Figure 12. The message sequence chart for a scheduling using [4]

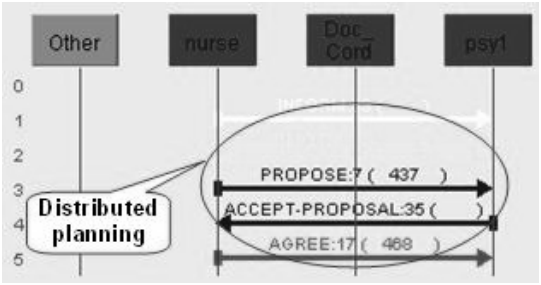

Figure 13. The message sequence chart for a scheduling using ABAH

6. RELATED WORK

The greater promotion of Internet and new technologies of information and communication are factors of homecare progress [21].

Authors base their works on the development of health centers as [22] which is a virtual medical center (VMC), its function consists in an intelligent central process where patients are evaluated. In [23] the author had the idea of an intermediate contact center between the patient and the medical staff, to improve the quality of service. Authors in [24] developed a collaboration system (Groupware) "Yuitori Network". It is a teamwork software

whose the purpose is to facilitate the sharing and information exchange.

Within the framework of the TIPHAD and COQUAS project [5], authors contribute at a system to reach the distributed information, and organize the supervision of the process homecare by describing the contribution of the mobile technology. In [2] authors have developed a distributed coordination platform (Workflow-based). The services are supplied thanks to an intermediation platform "RITHME" used with the aim of an intranet communication between the health professionals.

To resolve complex problems in a distributed way, authors directed their works to the agent technology. For [24], it set up agent-based architecture to improve the control, the surveillance and services supplied by the Medical Center Contact (MCC). Patients are affected by a chronic disease within the homecare framework. Several agent types participate like intermediary, information, monitoring, and visualization agent. The leading part of agents is the perception of the environment states (MCC) and the corresponding acts. For[4] , the homecare scenario is restricted (the services organism, the helpers and the customers). The proposed architecture is based on a multi-agent system: (i) Interface agent between the system administrator and the system (ii) Scheduler agent to manage the planning (iii) Helper agent assigned to every help agent, it detains the plan care and the Helper personal information. The planning is realized in an automatic way thanks to agents' negotiation. For the SAPHIRE project [25], it is the development of a surveillance system for an intelligent health's care helping to take a medical decision, based on the platform MSHCP (Multi-service's Homecare Platform). The medical devices are under surveillances of software agents interconnected to the medical information systems.

7. DISCUSSION

According to these works we notice, in particular, the lack of a generic system of homecare because of scenarios' variety, actors and their activities, this leads to problems in portability, reusability and interoperability. Also, authors consider the homecare as a simple service supplied by an organism of health, and those who perceive it as a complex system which requires for a distinct cooperation from all partners. Thereof, we tried to classify the works by considering the technology used as criterion of classification:

- The computerized medical file
- Groupware (to improve the group work)
- Telecommunication and wireless
- Intelligent house and pervasive computing (information in any moment)
- Agent technology
  - Cooperation inter-partners.
  - Coordination (planning, scheduling).

Every solution is oriented for a well determined disease, that we organize them in three types of categories:

- Chronic diseases
- Old persons
- Other (pediatrics, psychology etc.)

However, the interoperability is seen according to two levels: (i) interoperability was simply translated by the communication (connectivity) within the homecare network, (ii) interoperability translated by the connectivity, the exchange and the sharing of information (middleware, intermediate platform).

Other important point is that according to the literature which we consulted, architectures were proposed for the homecare of which some foresee the ontology, but which was not developed.

ABAH is an architecture which allows to see the homecare as a simple organization of a set of interconnected cooperative systems, which opens new perspectives of flexibility, and adaptability to applications dedicated to the homecare. It allows a supple communication between partners. This allows the sharing, the fast and supple exchange of structured information (messages, documents) according to the activity events. This flexibility allows to meet the homecare needs in continuous evolution. The ABAH system focuses on the patient. So, our efforts are dedicated on the communication, the coordination, and the cooperation enters all the system partners. So that these last ones make the good decision. It brought us to a confrontation in: (i) diverse information (ii) wide quantity of data brought back by the multi-field members of the team (iii) distribution and traffic of information (iv) tasks complexity (the high number and the variety of partners' activities, the complexity linked to the growth and to information volume to be processed and the

organization's difficulty, i.e. complexity of decision-taking which depends on the dynamics of the care process and on the evolution of the patient state). Indeed, in this solution we tried to surmount certain number of obstacles and problems such as:

- Interoperability (technical, syntactic and semantic based on ontology);
- Partners' interaction;
- Scalability.

Rest that medical information system makes the stakes rise with regard to the other domains and their intervention field is in essence without limit.

Throughout our work we followed a methodology of development based on three essential stages which are: needs specification, design (based on the cooperation) and implementation. We can say that the process followed for the OntoPAD construction allowed us to manage finally to build a domain ontology, heavy, of granularity neither rather fine nor rather wide and formal. The OntoPAD major trump consists in its coherence as well as its consistency shown by the tests made on it.

It is very likely that OntoPAD is sufficient to represent all the knowledge of this domain which evolves ceaselessly. It is thus a question of spreading this ontology and following its evolution during services configuration which have to adapt themselves to the evolution of users' needs, or still the new services constantly under development, the new partners who can intervene as well as of new tasks realized with the patient, etc.

8. CONCLUSION

In this paper we presented the interaction in an agent-based architecture, named ABAH, for a CIS supporting the homecare. This architecture is composed of a set of autonomous agents adapted to the interaction. Every agent represents an autonomous partner. These partners are geographically scattered belonging to heterogeneous information systems. ABAH is represented as a society of agents which forms a cooperative and intelligent multi-field system to satisfy a common purpose which is the total care of the patient at home. This architecture facilitates the interaction, the interoperability, and the accessibility to information. ABAH is independent from any application in the field of patient care at home (chronic diseases, independent persons, etc.). In particular, the knowledge is completely distributed between agents and thus assuring the flexibility. Furthermore, OntoPAD participated to surmount the problem of the semantic interoperability indispensable to the interaction and information exchanges between agents.

In the current state we are inclined to the evolution and always the experiment of ABAH, to determine difficulties and possibly, to envisage several improvements or possible extensions to the system. Like the implementation of a dedicated security system, with the aim of guaranteeing the respect for the medical secret, the data security and functionalities accessible to partners, to assure the coherence in terms of the data confidentiality and the deontology. OntoPAD is ready for a future evaluation within any application in touch with the domain which it models.

REFRENCES:

[1] N. Zarour, M. Boufaida, and L. Seinturier, "A Negotiation Framework for Organizational Information Systems", *International Journal of information Technology and Decision Making (IJITDM)*, World Scientific Publishing Co., vol. 3, n°2, June 2004, pp. 213-238.

[2] N. Bricon-Souf, F. Anceaux, N. Bennani, E. Dufresne, and L. Watbled, "A distributed coordination platform for homecare: analysis, framework and prototype", *International Journal of Medical Informatics* (2005) 74, 809—825.

[3] E. Shakshuki, H. Ghenniwa, and M. Kamel, "an architecture for cooperative information systems", Knowledge-Based Systems 16 (2003) pp. 17–27.

[4] G. Itabashi, M. Chiba, K. Takahashi, and Y. Kato, "A Support System for Home Care Service Based on Multi-agent System", *ICICS 2005*.

[5] F. Anceaux, N. Bennani, N. Bricon-Souf, L. Watbled, M. Beuscart-zéphir, and S. Lecomte, "Prise en charge de patients à domicile: un contexte nécessitant l'élaboration de systèmes d'informations coopératifs", *Revue des Sciences et Technologies de l'Information*, Série Ingénierie des Systèmes d'Information, 8, 2003, pp.75-93.

[6] V.G., Koutkias, I. Chouvarda, and N. Maglaveras, "A Multiagent System Enhancing Home-Care Health Services for Chronic Disease management", *IEEE Transactions on Information Technology in Biomedicine*, vol. 9, no. 4, december 2005.

[7] K. Zarour, and N. Zarour, "an Agent-Based Architecture for a Cooperation Information System Supporting the Homecare", *In Proceedings of International Workshop on Advanced Information Systems for Enterprises IWAISE 08*, April 19-20 2008, pp. 63-69, Constantine, Algeria.

[8] K. Zarour, "The Interoperability in a Cooperative Information System Supporting the Homecare", *In*

Proceedings of IACe-T' 2008, pp. 91-96, Amman – Jordan.

[9] http://www.fipa.org/

[10] S. A. Petersen, and M. Divitini, "Using Agents to Support the Selection of Virtual Enterprise Teams", *In Proceedings of Fourth International Bi-Conference Workshop on Agent-Oriented Information Systems (at AAMAS 2002)*, AOIS-2002, Bologne, Italy, July 2002.

[11] P. Degoulet, and M. Fieschi, "Informatique Médicale". Abrégé Masson 1998.

[12] B. Orgun, and J. Vu, "HL7 ontology and mobile agents for interoperability in heterogeneous medical information systems", *Computers in Biology and Medicine* 36 (2006) 817–836.

[13] http://www.w3.org/TR/2004/REC-webont-req-20040210/

[14] http://protege.stanford.edu/

[15] J.A. Fraile, D.I. Tapia, S. Rodríguez, and Corchado J.M., "Agents in Home Care: A Case Study". *HAIS* 2009, LNAI 5572, pp. 1–8, 2009.

[16] J.A. Fraile Nieto, M.E. Beato Gutiérrez, and B. Pérez Lancho, "Developing Home Care Intelligent Environments: From Theory to Practice", *7th International Conference on PAAMS'09*, AISC 55, pp. 11–19.

[17] Uschold, M., and King, M. "Towards a Methodology for Building Ontologies". In D. Skuce (Ed.), *IJCAI'95 Workshop on Basic Ontological Issues in Knowledge Sharing*, (pp. 6.1-6.10). Montreal, Canada, 1995.

[18] M. Fernández-López, A. Gómez-Pérez, and N. Juristo, "METHONTOLOGY: From Ontological Art Towards Ontological Engineering". *Spring Symposium on Ontological Engineering of AAAI* , 33–40, 1997.

[19] F Bellifemine, G Caire, T Trucco, and G Rimassa, "Jade Programmer's Guide, JADE 3.4". Available at http://sharon.cselt.it/projects/jade/

[20] V. Lesser, K. Decker, T. Wagner, N. Carver, B. Horling, D. Neiman, R. Podorozhny, M. Nagendra Prasad, A. Raja, R. Vincent, P. Xuan, and X. Q. Zhang, "Evolution of the GPGP/TÆMS Domain-Independent Coordination Framework", *Autonomous Agents and Multi-Agent Sytems*, 9, 87–143, 2004, Kluwer Academic Publishers, Manufactured in The Netherlands 2004.

[21] S. Koch, "Home telehealth-Current state and future trends", *International Journal of Medical Informatics (2006)* 75, 565—576.

[22] Y. Liu, "The Design and Implementation of a Virtual Medical Centre for Patient Home Care", *Proceedings of the 20th Annual International Conference of the IEEE Engineering in Medicine and Biology Society*, Vol. 20, No 3,1998.

[23] N. Maglaveras, I. Chouvarda, V.G. Koutkias, G. Gogou, I. Lekka, D. Goulis, A. Avramidis, C. Karvounis, G. Louridas, and E.A. Balas, "The citizen health system (CHS): a Modular medical contact center providing quality telemedicine services Information Technology in Biomedicine", *IEEE Transactions on* Volume 9, Issue 3, Sept. 2005 Page(s):353 – 362.

[24] T. Mitsuishi, Y. Kimuras, A. Ogawa, H. Kamata, J. sasaki, and Y. Funyu, "A Case Study on Construction of Groupware: Yuitori Network for Health", *Welfare and Medical Works on Home Care ICPADS'*2000.

[25] A. Hein, O. Nee, D. Willemsen, T. Scheffold, A. Dogac, and G.B. Laleci, "SAPHIRE - Intelligent Healthcare Monitoring based on Semantic Interoperability Platform – The Homecare Scenario –" *1st European Conference on eHealth (ECEH'06),* Fribourg, Switzerland, October 12 – 13, 2006.